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FOR

MULTIPROCESSOR NOTEBOOK COMPUTER WITH A TABLET PC CONVERSION CAPABILITY

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MULTIPROCESSOR NOTEBOOK COMPUTER WITH A TABLET PC CONVERSION CAPABILITY

FIELD OF THE INVENTION

[0001] The present invention relates generally to the field of computer systems. More particularly, the present invention relates to a method and apparatus for a multiprocessor notebook computer with a tablet personal computer (PC) conversion capability.

BACKGROUND OF THE INVENTION

[0002] Computer systems have become increasingly pervasive in our society. The processing capabilities of computers have increased the efficiency and productivity of workers in a wide spectrum of professions. As the costs of purchasing and owning a computer continues to drop, more and more consumers have been able to take advantage of newer and faster machines. Furthermore, many people enjoy the use of notebook computers because of the freedom. Mobile computers allow users to easily transport their data and work with them as they leave the office or travel. This scenario is quite familiar with marketing staff, corporate executives, and even students.

[0003] Despite the physical dimensions of existing notebook computers, there is interest in the market for computing devices with even thriftier form factors. For instance, personal digital assistants and cellular phones with calendar functions are growing in popularity. However, the computing power and capabilities of such devices are somewhat limited. A user is still required to lug a notebook system around even though not all such functionality is necessary at all times. Similarly, the present mobile

computers generally include low power microprocessors and accompanying components. The tradeoff for such power savings is often the available horsepower. This can also prevent a user from running some heavy tasks or applications on a mobile computer. Even though current electronic tools provide the freedom and mobility of a traveling office, the technology continues to evolve.

[0004] Some notebooks with docking station capabilities exist currently for use at the desk. However, these docking stations provide expansion ports for additional devices not normally contained within the computer housing. But when the notebook is disconnected from the docking station, all of the functions and capabilities of the docking base are no longer available to the notebook. Similarly, the processing capabilities of the notebook computer are not available to the docking base when disconnected.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The present invention is illustrated by way of example and not limitations in the figures of the accompanying drawings, in which like references indicate similar elements, and in which:

[0006] **Figure 1A** is an illustration of a multiprocessor computer system having a capability to separate into a tablet PC and a server PC in accordance with the present invention in its mated state;

[0007] **Figure 1B** is an illustration of the multiprocessor computer system of **Fig. 1A** in its detached mode;

[0008] **Figure 2** is a block diagram of components located within an embodiment of a convertible dual processor computer system;

[0009] **Figure 3** is a block diagram of another embodiment of a dual processor mobile computer system that can detach into separate computing devices;

[0010] **Figure 4** is a flow chart showing one embodiment of a method to initialize a convertible dual processor computer in accordance with the present invention.

DETAILED DESCRIPTION

[0011] A method and apparatus for a multiprocessor notebook computer with a tablet personal computer (PC) conversion capability is disclosed. The embodiments described herein are described in the context of a mobile computer, but are not so limited. Although the following embodiments are described with reference to a notebook computer system, other embodiments are applicable to other portable computing devices and other handheld electronic devices. The same techniques and teachings of the present invention can easily be applied to other types of devices or systems that can benefit from a multiprocessor notebook computer with tablet PC conversion capability.

[0012] In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. One of ordinary skill in the art, however, will appreciate that these specific details are not necessary in order to practice the present invention. In other instances, well known electrical structures and circuits have not been set forth in particular detail in order to not necessarily obscure the present invention.

[0013] Embodiments of the present invention can provide an enhanced notebook computing model. Superior performance can be obtained with a dual processor convertible computer system while still providing a power efficient mobile solution. The system can take advantage of present day operating systems and software applications that users desire. Furthermore, the multiprocessor capabilities of such as system also provides an avenue to future software packages that require greater processing power than that available in existing single processor notebook machines. Implementation of

the present invention can allow for flexibility in terms of compute capability and power consumption without sacrificing horsepower or functionality.

[0014] This computer system is actually two computers attached together. The notebook system of one embodiment has a convertible tablet top half containing some redundant components to those in the bottom half. Depending on the particular implementation, the two computers, through the use of hardware and/or software, are capable of utilizing resources in both halves of the system like a distributed processing system. A system in accordance with the present invention is a multiprocessor mobile device that can take advantage of distributed processing and secondary resources when the two halves are connected, but can also work independently when the tablet portion is detached from the base module. For one embodiment, the model comprises of two logical computers wherein the lower half with high performance processor becomes a server, while the upper half becomes a client computer. The operating systems and software running independently yet cooperatively in each half of the system are able to take advantage of both processors in the system when the units are connected into single notebook system. The tablet PC portion of the system is a fully functional, portable computing device when detached.

[0015] A computer system having a notebook form factor can be configured to include a detachable display which converts into a tablet PC. Each half of the notebook system contains a virtually full feature computer wherein each half can leverage the other half when connected in a distributed computing model. The upper display portion of the system may contain enough complimentary computer components such that it looks like a totally complete computer. Both halves of the convertible notebook system would have

its own processor, memory, data storage, etc. For this embodiment, when the upper half of the notebook is detached, this upper half takes control of its display screen. But in normal connected mode, the upper half defers all screen management and display input to the lower portion of the notebook unit. In the detached mode, the upper half acts as a tablet PC, while the lower half can operate as a functional server and to provide additional computing functions available to the upper half. In another embodiment, components may only reside in the portion of the system that makes the most sense. In the case of the graphics controller, it may make sense to provide duplicate graphics controllers wherein the one in the base unit has more capabilities with higher power consumption, while the graphics controller in the upper half of the system is tailored for battery operation using less power. It is possible to include only one graphics controller in the tablet portion of the system which is controlled in docked mode by software running in the base portion of the system.

[0016] **Figure 1A** is an illustration of a multiprocessor computer system having a capability to separate into a tablet PC **151** and a server computer **101** in accordance with the present invention in its mated state. In the mated mode, the system appears as a mobile notebook computer. The system of this embodiment has multiprocessing capability due to a first processor located in the first computer underneath the keyboard of the notebook and a second processor located beneath the display screen. The notebook system may be used as a portable machine or connected to a network, where the system can access other computers or even perform as a server.

[0017] **Figure 1B** is an illustration of the multiprocessor computer system of **Fig. 1A** in its detached mode. The notebook system of this embodiment can be separated **130** into

two individual computers **101**, **151**, each having full processing capability. The first computer is a base computer **101** that can function as a server machine if connected to a network. The second computer is a thin, lightweight tablet PC **151** that a user can easily carry around and use when large, unwieldy peripherals such a keyboard or disk drive are not convenient. This tablet PC **151** offers size and weight advantages where it is inconvenient to carry around a notebook machine. The base computer **101** and the tablet PC **151** are also capable of wireless communication with each other for the sharing and access of data and resources. The two halves of the notebook system can be treated as two totally independent computers by the operating environment. Even though they are packaged into the same package, both halves of the system run an operating system software intended for the distributed computing environment. In its normal mode wherein both halves of the computer are together, the primary processor downloads tasks to the secondary processor. In the detached mode of operation depicted in **Fig. 1B**, user input is through a touch screen / pen input interface of the screen itself. In the connected mode shown in **Fig. 1A**, user input is through the keyboard as well as through the touch screen.

[0018] **Figure 2** is a block diagram of components located within an embodiment of a convertible dual processor computer system **200**. For this embodiment, the computer system **200** is configured like a mobile notebook computer having clamshell design. The clamshell is formed with a display screen top portion **251** and a keyboard bottom portion **201**. The top and bottom portions are connected together at a hinge type mechanism at segment **298**. A connection bus at this hinge **298** can provide electrical connectivity between the two halves of the system and to allow for communications and

synchronization. For this embodiment, the hinge apparatus has a multi-pin docking connector. The system **200** can be closed and folded up by shutting the top portion over the bottom portion **201**. Unlike typical notebook computers, the dual processor system of this embodiment can be converted into two individual stand-alone computers upon separation at mating line **298**. For example, the bottom portion **201** of the system **200** is a full function mobile computer wherein the various parts and components of the computer are located within the base of system under the keyboard. The top portion **251** of the system **200** is a tablet computer wherein its various parts and components are located within the lid of the system underneath the display screen.

[0019] The base computer **201** in the bottom portion of the notebook system **200** is the primary computer in this embodiment. A primary processor unit **202**, primary data storage **210**, CD/DVD drive **216**, and a keyboard module **218** are in the bottom portion **201** of the system **200**. The keyboard module **218** controls the keyboard located on top of these components. A connectivity module **208** in the base computer **201** is to provide external ports and connectors for receiving cables from external devices. The wireless transceiver **206** is to send and receive wireless transmissions to/from the base computer **201**. For instance, the wireless transceiver **206** is used to communicate with the tablet PC **251** when the two portions are detached from each other. The wireless transceivers also provides a user with the ability to form a wireless connection between the two halves of the system such that the tablet portion of the computer can be detached for laptop use while the lower portion is stored in a briefcase or on a desk. Furthermore, the two portions can continue to be networked together via the wireless link so that the primary computer can distribute tasks to the other computer. The primary power module **212** is to

provide power to the base computer **201** when connected a wall outlet. The primary power module **212** also controls a rechargeable battery mechanism for the base portion **201**. An interface unit **204** is to handle the communications between the bottom base computer **201** and the top tablet computer **251** when the two portions are physically mated together.

[0020] The tablet computer **251** in the top portion of the notebook system **200** is the secondary computer in this embodiment. A secondary processor unit **252**, secondary data storage **260**, and a display module **266** are in the top portion **251** of the system **200**. The display module **266** controls the display screen located on top of these components. A connectivity module **258** in the tablet PC **251** is to provide external ports and connectors for receiving cables from external devices. The wireless transceiver **256** is to send and receive wireless transmissions to/from the tablet PC **251**. The secondary power module **212** is to provide power to the components in the tablet PC **201**. For one embodiment, the tablet PC **251** can be connected a wall outlet. The tablet PC **251** can also receive power through system connections **299** when the tablet PC **251** is physically mated with the base computer **201**. The secondary power module **262** also includes a rechargeable battery mechanism to power the tablet PC **251** when is unmated and away from the base computer **201**. An interface unit **254** is to handle the interaction between the bottom base computer **201** and the top tablet computer **251** when the two portions are physically mated together.

[0021] A system connections module **299** is to mate the top portion **251** and the bottom portions **201**. System connections is to also provide connectivity of data signals and power busing between the computers. The elements of the computer **201**, **251**,

perform their conventional functions well known in the art. Depending on the particular implementations, the rest of the systems **214**, **264**, can include various other computer components and peripherals. Similarly, the functionality and form factors of the components in the bottom portion **201** and the top portion **251** may differ even though similar names are used. For the embodiment of **Fig. 2**, the base computer **201** is assigned as the primary computer or master for the system **200**. Thus the requests and tasks of base computer **201** may be have higher priority that those of the tablet PC **251**. When the computers are detached, the master **201** can be requested to provide host services such as network access, CD/DVD drive reads, etc. for the tablet PC **251**. Furthermore, when the computers are attached together, the primary computer **201** may be set to control all the components in the overall combined system **200**. Similarly, the system **200** may be configured such that just the primary computer **201** is operating while the secondary computer **251** is idle or off, except for the display module **266**. In alternative embodiments, the system can be partitioned in any number of different ways and the actual components residing in the computers can vary and may or may not overlap. Even though the two computers have some redundant components, the operating systems and management software causes the devices in the system to operate in harmony.

[0022] A next generation notebook computer architecture in accordance with the present invention can provide a low power model without the sacrifice of a high performance model when AC power is connected and two halves of the notebook system are connected together. Referring now to **Figure 3**, an exemplary multiprocessor computer system **300** is shown. System **300** is representative of processing systems based on the PENTIUM® III, PENTIUM® 4, ITANIUM™ and/or STRONGARM™

microprocessors available from Intel Corporation of Santa Clara, California, although other systems (including PCs having other microprocessors, engineering workstations, set-top boxes and the like) may also be used. The computer system **300** of **Fig. 3** comprises of two separate computers: a base module computer **301** and a tablet PC **351**. In one embodiment, the computers **301**, **351**, may execute version of the WINDOWS™ operating system available from Microsoft Corporation of Redmond, Washington, although other operating systems and graphical user interfaces, UNIX and LINUX for example, may also be used. Furthermore, the particular operating systems executed on the computers **301**, **351**, may not be of the same version and/or type. For instance, base computer **301** may execute Microsoft WINDOWS XP or WINDOWS 2000, while tablet PC may execute Microsoft WINDOWS CE or PALM OS® from Palm, Inc. of Santa Clara, California. The operating software of the two computers **301**, **351**, should be compatible or at least able to communicate with each other. A secure data link may also be provided between the machines. Thus, the present invention is not limited to any specific combination of hardware circuitry and software. For this embodiment, software controls the interaction between the computers and the overall system. This software also allows the computers to share and synch data. A security mechanism may be added to either of the devices to prevent unauthorized access to data or use of resources.

[0023] **Figure 3** is a block diagram of another embodiment of a convertible dual processor mobile computer system **300** that can detach into separate computing devices **301**, **351**, in accordance with the present invention. The present embodiment is described in the context of a single processor desktop or server system, but alternative embodiments can be included in a multiprocessor system. Base module computer **301** is an example of

a hub architecture. The base computer **301** includes a processor **302** to process data signals. The processor **302** can be a complex instruction set computer (CISC) microprocessor, a reduced instruction set computing (RISC) microprocessor, a very long instruction word (VLIW) microprocessor, a processor implementing a combination of instruction sets, or any other processor device, such as a digital signal processor, for example. The processor **302** is coupled to a processor bus **310** that transmits data signals between the processor **302** and other components in the base computer **301**. The elements of base computer **301** perform their conventional functions well known in the art.

[0024] Base computer **300** includes a memory **320**. Memory **320** can be a dynamic random access memory (DRAM) device, a static random access memory (SRAM) device, flash memory device, or other memory device. Memory **320** can store instructions and/or data represented by data signals that can be executed by the processor **302**. An internal cache memory **304** can reside inside the processor **302** to store recently used data signals from memory **320**. Alternatively, in another embodiment, the cache memory can reside external to the processor **302**.

[0025] A system logic chip **316** is coupled to the processor bus **310** and memory **320**. The system logic chip **316** in the illustrated embodiment is a memory controller hub (MCH). The processor **302** communicates to the MCH **316** via a processor bus **310**. The MCH **316** provides a high bandwidth memory path **318** to memory **320** for instruction and data storage and for storage of graphics commands, data and textures. The MCH **316** is to direct data signals between the processor **302**, memory **320**, and other components in the base computer **301** and to bridge the data signals between processor bus **310**, memory

320, and system I/O **322**. In some embodiments, the system logic chip **316** can provide a graphics port for coupling to a graphics controller **312**. The MCH **316** is coupled to memory **320** through a memory interface **318**. The graphics module **312** is coupled to the MCH **316** through an Accelerated Graphics Port (AGP) interconnect **314**.

[0026] Base computer **301** uses a proprietary hub interface bus **322** to couple the MCH **316** to the I/O controller hub (ICH) **330**. The ICH **330** provides direct connections to some I/O devices via a local I/O bus. The local I/O bus is a high-speed I/O bus for connecting peripherals to the memory **320**, chipset, and processor **302**. The PCI protocol is commonly associated with a type of the local I/O bus. .Some examples are the data storage **324**, keyboard interface **326**, firmware hub (flash BIOS) **328**, and a network controller **329**. The data storage device **324** can comprise a hard disk drive, a floppy disk drive, a CD-ROM device, a flash memory device, or other mass storage device.

[0027] Base computer also includes a module for connectivity and expansion ports **331** such as Universal Serial Bus (USB) or a parallel port. A mating module **332** and wireless transceiver **334** are coupled to the ICH **330**. The mating module **332** of the base computer **301** mates with a corresponding mating module **382** of the tablet PC **351**. The mating module **332** is to provide a physical connection **333** between the base computer **301** and the tablet PC **351**. When the computers **301**, **351**, are mated together, the mating module **332** is to handle the sending and receiving of data, instructions, control signals, and power. Similarly, the wireless transceiver **334** of the base computer **301** is to handle the sending and receiving of data and instructions with the wireless transceiver **384** of the tablet PC **351**. The wireless transceivers **334**, **384**, can form a wireless link **335** in accordance with a local area wireless protocol such as the IEEE 802.11a standard, IEEE

802.11b standard, or Bluetooth technology, for example. Wireless link **335** can be one of the standard wireless protocols or a proprietary, non-standard wireless interface. The wireless transceivers **334**, **384**, are not limited to communications with each other and may also communicate with other wireless devices.

[0028] For this embodiment, the tablet PC **351** comprises a similar hub architecture to that of the base computer **301**. A processor **352** is coupled to a processor bus **360** to transmit data signals between the processor **352** and other components in the tablet PC **351**. MCH **366** couples the processor **352** to memory **370** and tablet PC I/O **372**. An ICH **380** is coupled to the MCH **366**. The peripheral devices coupled to the ICH of this embodiment includes data storage **374**, flash BIOS **378**, connectivity and expansion ports **381**, mating module **382**, and wireless transceiver **384**. Even though the components in of the base module computer **301** and tablet PC **351** bear similar names, the exact functionality and form factor may not necessarily be identical. For instance, the components in the tablet PC may be optimized to be lightweight and low power, whereas the components in the base computer may be optimized for higher performance.

[0029] A graphics module **362** is coupled to the MCH **366** though AGP interconnect **362**. A display module **376** is coupled to receive graphics data from the graphics module **362**. A screen interface **377** couples the display module **376** to the ICH **380**. The display module **376** of the tablet PC of this embodiment is a lightweight liquid crystal display (LCD) flat-panel display screen. This display module **376** also comprises a touch-sensitive transparent panel covering the LCD screen. The screen interface **377** in this embodiment is to receive user input via the touch screen and to propagate the input data to the processor **352** through the ICH **380**.

[0030] Although the architectures of the base module computer **301** and the tablet PC **351** are similar, the computers of this embodiment is configured different. For example, the base computer **301** may be optimized for faster performance and network connectivity. The base computer **301** of this embodiment can be connected to a network to perform as a server machine. Thus when the processing capability on the base computer is used, another computer on the network may be able to access this base computer **301** and borrow the computing resources. Similarly, the tablet PC **351** may be optimized for better mobile performance. The tablet PC **351** can be used where full computing functionality such as a keyboard or large display is not needed.

[0031] When the base computer **301** and tablet PC **351** of this embodiment are joined together at the mating modules **332, 382**, the mated configuration is a multiprocessor notebook computer. The base computer **301**, having a keyboard, serves as the bottom half of the notebook clamshell. The tablet PC **351**, having a LCD display screen, serves as the top portion of the notebook machine. In this mated mode, a user can set the system **300** to operate with a single processor or with multiple processors. For instance, if high performance or a large amount computing power is needed, the system **300** may be set to operate with both processors **302, 352**. The base computer **301** can have a single processor or even multiple processors depending on the performance and power consumption requirements of the particular implementation. But if normal performance or greater power savings is desired, the system **300** may be set to operate with just one of the processors **302, 352**. While the base module **301** and tablet PC **351** are physically mated, data can be communicated over the physical link **333** and synchronized. Depending on the particular implementation, the data stored on the two computers **301**,

351, may be identical or not. In one embodiment, the tablet PC **351** may be used as a convenient portable digital notepad wherein the user wants to have all the data of the base module **301** available on the tablet PC **351** and any notes taken on the tablet PC **351** available on the base computer **301**. Thus the stored data from the base module **301** may be replicated during synchronization with the tablet PC **351** and vice versa. In another embodiment, the data on the base computer **301** and tablet PC **351** may be different and not replicated, but simply shared between the computers **301**, **351**, when mated together or through wireless communications.

[0032] When the base computer **301** and tablet PC **351** are detached, each one has the capability to operate as stand-alone single processor computers. By physically detaching the tabled PC **351** from the base computer **301**, the multiprocessor notebook computer system **300** is converted into a separate base module computer **301** and a tablet PC **351**. Because the display of the system **300** resides with the tablet PC **351**, the base computer **301** is left without a display when in the detached mode. A monitor can be coupled to the graphics module **312** of the base computer **301** if a display is needed. For this example, only one graphics controller **312** or **362** is necessary to operate the display. When both graphics controllers **312**, **362**, are available in the connected mode of operation, one of the controllers is turned off to reduce power consumption. Similarly, other redundant components within the system may be turned off in the mated mode. In addition to the possible power savings, thermal output can also be reduced. Normally, the detached base computer **301** of one embodiment is left connected to a network to provide network access to the tablet PC **351** and the sharing of computing resources when the base computer **301** is idle or under utilized. In the detached mode, the tablet PC **351** of this

embodiment does not have a keyboard or physical network connection. User input is made via a LCD touch screen interface **377** on the tablet PC **351**. The wireless transceiver **384** of tablet PC **351** can form a wireless link **335** with the wireless transceiver **334** of the base computer **301** and thus access the network by the network link of the base computer **301**.

[0033] **Figure 4** is a flow chart showing one embodiment of a method to initialize a convertible dual processor computer in accordance with the present invention. This example generally describes the initialization procedure of a base module computer of one embodiment during a system startup or reset. At block **402**, the base computer emerges from a system startup or reset sequence. The base computer performs a hardware check of onboard components and devices at **404**. This hardware check can entail a query to determine what components and devices are physically present in the base computer and whether they are operational. For this embodiment, these onboard components and devices can include items physically connected to the motherboard like a hard disk drive, floppy drive, CD ROM drive, bus controller, wireless transceiver, and/or video card. The operating system is loaded at block **406**. At block **408**, the hardware devices found during the hardware checks of block **404** are initialized and configured for use. The base computer performs a search for a physically connected tablet computer at block **410**.

[0034] At block **412**, the base computer checks whether any tablet PC is found physically mated. If a tablet PC is found physically mated with the base computer at block **412**, then the base computer initializes and configures the physical interface between the computers at block **414**. For one embodiment, the configuration of the

physical interface entails a handshaking process between the mating/communication modules. At block **416**, the base computer determines what user model is requested. For example, the convertible dual processor notebook computer of this embodiment can operate in at least three different modes: (1) multiprocessor notebook computer with mated base computer and tablet PC; (2) single processor notebook computer with mated base computer and tablet PC; and (3) detached single processor base computer with detached single processor tablet PC. Because the example method of **Fig. 4** describes the initialization at the base module computer, block **418** comprises evaluating the user setting at the base computer whether a single processor mode is desired. If a single processor mode is requested, the system assumes normal operation as a single processor computer at block **428**. Depending on the particular implementation, either one of the processors available in the system (one in the base computer and one in the tablet PC) may be used in the single processor mode. If a multiprocessor mode is requested at block **418**, the system assumes normal operation as a dual processor computer at block **420** with both processor active.

[0035] But if no tablet PC is found physically connected at block **412**, the wireless transceiver of the base computer is initialized and configured at block **422**. The base computer then performs a search for wireless devices in the vicinity at block **424**. The wireless device of interest here is the wireless tablet PC. At block **426**, a check is made as to whether any wireless connections were detected. If no wireless signal is detected from the tablet PC, the base computer is alone and operates as a stand-alone computer. The system in this instance comprises of the single processor base computer. Thus, the system assumes normal operation as a single processor computer at block **428**. If a

wireless connection is made with the wireless tablet PC at block **426**, the system is operating within the detached single processor base computer and detached single processor tablet PC mode. At block **430**, the system assumes normal operations as a multiprocessor system wherein the separate tablet PC and base computer can be in wireless contact. For one embodiment, the detached tablet PC and base computer operate separate from each other and communicate wirelessly when data on the other machine is needed. For an alternate embodiment, the detached tablet PC may continually communicate with the base computer in order to borrow the processor resources or to access an attached network.

[0036] In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made thereof without departing from the broader spirit and scope of the invention as set forth in the appended claims. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.